

# PERMIAN FAUNAS AND SEDIMENTS FROM THE SOUTH MARULAN DISTRICT, NEW SOUTH WALES

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(Plates XIV–XV)

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## *Synopsis*

A richly fossiliferous Permian outlier is described from the South Marulan District. Fauna and flora consist of 41 species of which one, *Elimata prima* is new. Correlation of these sediments with beds situated about the Wandrawandian Siltstone-Nowra Sandstone boundary in the South Coast Permian sequence is suggested.

The spatial arrangement of pelitic sediments containing leaves, and sandstones containing a marine fauna enables interpretation of the beds as lagoonal and littoral shoreline deposits which are associated with a Permian transgression. Alternatively, they may represent a simple stratigraphic sequence.

## INTRODUCTION

The earliest workers in the Marulan-South Marulan district, approximately 120 miles south-west of Sydney, were Woolnough (1909) and Craft (1931). Studies made by Osborne (1931, 1949) and Osborne and Lovering (1952) considered petrological aspects of the batholithic and related rocks. Additional unpublished results are included in theses by Hind (1950), Lovering (1950) and Svenson (1950). Woolnough (1909, p. 786) and Craft (1931, Text-fig. 2) record the small areas of Permian sediments overlying older rocks. The most recent geological map of the area, the Wollongong 1:250,000 Geological Series Sheet SI 56–9 (2nd edn) has been compiled by the Geological Survey of New South Wales. This shows the south-westerly extent of Permian strata referred to the Megalong Conglomerate and undifferentiated Berry Formation to be approximately 4 miles north-east of Permian sediments described herein. One or two isolated outcrops also occur on the Ordovician-Devonian contact approximately 1½ miles north-east of South Marulan.

Pertinent differences can be observed between this map and the geology represented on Text-fig. 1, the latter resulting from a study by Gould (1966). The Silurian acid volcanics and interbedded sediments are separated from Devonian batholithic rocks. On the Wollongong 1:250,000 geological map the distribution of these units suggests that they are not completely separated. Another major difference is that the fault separating Ordovician and Silurian strata near South Marulan is interpreted here as an unconformity.

## GENERAL PALAEOZOIC STRATIGRAPHY

The lowest stratigraphic unit is the Tallong beds. They are composed of an undifferentiated sequence of isoclinally folded slates, quartzites and phyllites considered by Sherrard (1949) to be late Upper Ordovician in age.

Unconformably overlying the Tallong beds is the Bungonia limestone. The basal portion is massive limestone but this becomes increasingly arenaceous towards the top. Because of the associated fauna, *Favosites*

*gothlandicus* and *F. allani*, *Heliolites*, *Tryplasma*, stromatoporoids and pentamerid brachiopod casts (Svenson, 1950; Flinter, 1950; Gould, 1966) the unit is regarded as Middle-Upper Silurian in age. Toscanites, tuffs and tuffaceous labile and sublabile sandstones with minor pelites previously included in the batholithic rocks are named the Tangerang volcanics. On field evidence they are considered to overlie conformably the Bungonia limestone and to be Upper Silurian in age, probably extending into the Lower Devonian.

The Glenrock granodiorite, a term used by Woolnough (1909) for a major component of the Marulan Batholith, intrudes the three units already discussed. Naylor (1939) and Browne (1950) assign to the granodiorite a probable late Middle Devonian and a Tabberabberan age respectively.

Permian sediments are composed of leaf-rich pelites and fine to medium grained labile and sublabile calcareous sandstones which contain a rich marine fauna and plant detritus. Their position on the Bungonia limestone-Tangerang volcanics contact coincides with a major physiographic break which extends in a southerly direction towards the Shoalhaven River gorge. They outcrop approximately one mile south-west of South Marulan at Grid Ref. 70493024 Wollongong 1:250,000 geological map. Outcrop, which is mainly rubble, covers a kidney-shaped area of approximately 40,000 square yards.

The pelites in the southern portion of the outcrop are composed of 95% clay size particles and brown organic matter, probably leaves. There are small amounts of quartz, zircon and mica.

The major portion of the body consists of detritus comprising quartz (45%), feldspar (25%), rock fragments (25%) with accessory muscovite, biotite and heavy minerals, including hornblende, tourmaline and opaques. Matrix constitutes up to 5% of the rock. Sorting is fair with grains ranging in size from 0.05 mm. to 2.5 mm. in mean diameter. Mineral grains are angular to subangular while most lithic fragments are subrounded to rounded.

Quartz grains cover the entire grain size range and are dominantly of two types. Some grains show undulose extinction, mosaic domains and often with included zircon needles, minute dusty inclusions and rare feldspar laths. The second type commonly exhibits clear extinction and trails of small inclusions. Fragment shapes often suggest hexagonal peripheries while pseudo-inclusions and resorbed rims are apparent.

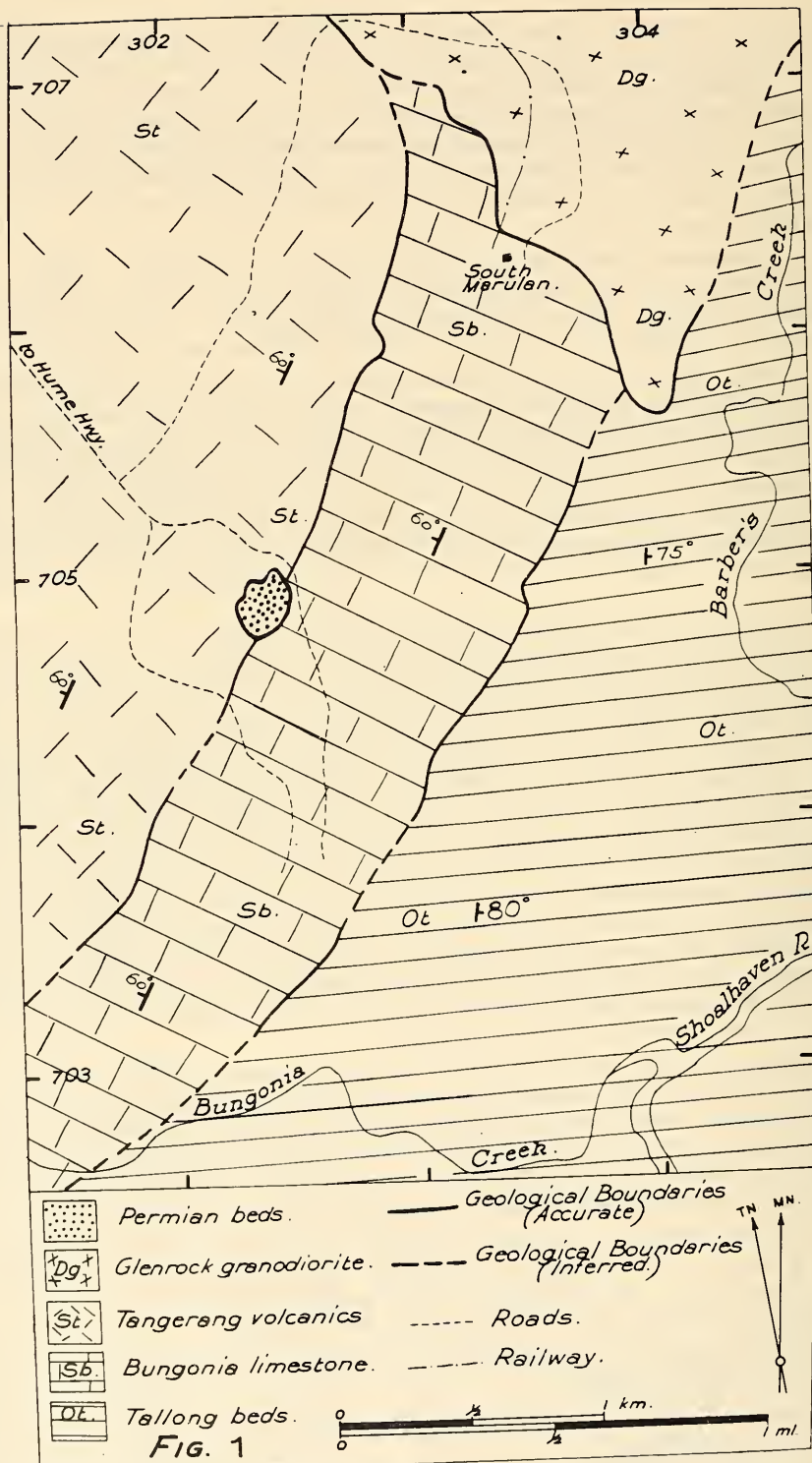
Feldspar grains generally range in mean diameter from 0.4 mm. to 1.0 mm. although rare grains are only 0.05 mm. across. Potassic feldspar and plagioclase occur in approximately equal proportions. K-feldspar is often perthitic and may show sericitisation. Rare myrmekitic growths rim some grains. Some show crosshatched twinning and may be identified positively as microcline. Plagioclase is more commonly altered to chloritic products.

Colourless muscovite and altered biotite flakes are scattered throughout. Heavy minerals are accessory and consist of (i) opaques, (ii) amphibole lath fragments up to 0.5 mm. long, mostly chloritised and (iii) rare tourmaline, pleochroic from blue-green to yellow-green.

Lithic fragments generally show extensive alteration and may be separated into four groups:

(i) acid volcanics showing embayed quartz, feldspar and biotite in a once glassy mesostasis,

(ii) granitic fragments composed of a mosaic of quartz grains and perthitic feldspar,



Text-fig. 1. General Geological Map of the South Marulan area (after Gould, 1966).



(iii) trachytic (?) fragments with abundant feldspar laths defining a flow foliation in a once glassy ? groundmass, and

(iv) rare and extremely fine grained fragments of slates.

Matrix consists of very fine detrital grains with abundant clay minerals. Patchy iron staining is prevalent. Post depositional mineralogical change is evident where areas of complete chloritisation occur. The chlorite forms intergrowths of radiating spherules. These are colourless to pale yellow and generally show grey interference colours but are rarely isotropic.

Consideration of detritus present indicates three major sources.

1. The Tangerang volcanics as evidenced by the second type of quartz discussed and also by recognisable acid volcanic fragments,

2. the batholithic rocks themselves due to the first type of quartz and granitic fragments, and

3. the regionally metamorphosed Tallong beds as evidenced by slate fragments and the pleochroic tourmaline, characteristic of these strata.

#### FAUNA AND FLORA

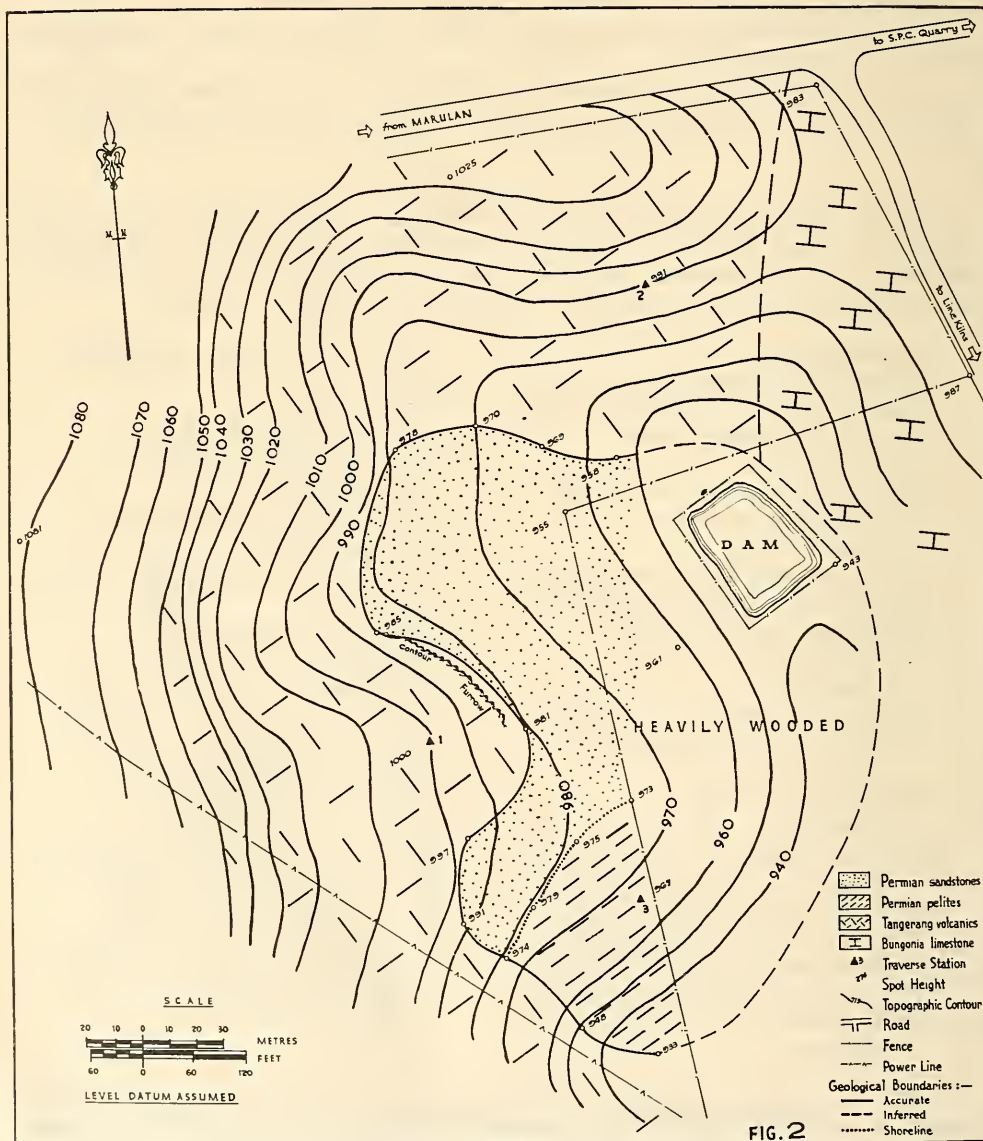
Fauna and flora identified are listed below. The fauna occurs in the sandstone. Leaf detritus is found dominantly in the pelites but some is enclosed in the sandstone. In the list, an asterisk (\*) indicates the species is discussed later and a stroke (/) indicates the species is figured.

<i>Cladochonus</i> sp.	<i>Terrakea solida</i> (Etheridge and Dun)
<i>Conularia inornata</i> Dana	
<i>Conularia</i> cf. <i>tuberculata</i> Fletcher	*/ <i>Terrakea</i> sp.
<i>Fenestella canthariformis</i> (Crockford)	<i>Trigonotreta stokesi</i> Koenig
<i>Fenestella dispersa</i> (Crockford)	/ <i>Pleurikodonta</i> cf. <i>elegans</i> Runnegar
<i>Fenestella granulifera</i> (Crockford)	<i>Atomodesma</i> ( <i>Aphanaia</i> ) sp.
<i>Polypora woodsi</i> (Etheridge, Jr)	*/ <i>Conocardium</i> sp.
<i>Protoretepora ampla</i> (Lonsdale)	<i>Aviculopecten subquiquelineatus</i> McCoy
*/ <i>Stenopora gracilis</i> (Dana)	*/ <i>Elimata prima</i> sp. nov.
<i>Ambikella</i> cf. <i>ingelarensis</i> (Campbell)	*/ <i>Stutchburia costata</i> (Morris)
/ <i>Ambikella</i> cf. <i>isbelli</i> (Campbell)	<i>Schizodus</i> sp.
<i>Ambikella</i> cf. <i>mantuanensis</i> (Campbell)	<i>Vacunella</i> cf. <i>curvata</i> (Morris)
/ <i>Ambikella</i> cf. <i>undulosa</i> (Campbell)	<i>Merismopteria</i> sp.
*/ <i>Fletcherithyris</i> cf. <i>amygdala</i> (Dana)	<i>Myonia corrugata</i> ? Fletcher
/ <i>Fletcherithyris parkesi</i> Campbell	<i>Keeneia minor</i> (Fletcher)
/ <i>Gilledia ulladullensis</i> Campbell	<i>Keeneia ocula</i> (Sowerby)
*/ <i>Notospirifer</i> cf. <i>minutus</i> Campbell	<i>Peruvispira</i> cf. <i>elegans</i> (Fletcher)
/ <i>Strophalosia clarkei</i> Etheridge Sr	<i>Peruvispira triflata</i> (Dana)
<i>Strophalosia clarkei</i> var. <i>minima</i> Maxwell	<i>Strotostoma inflata</i> Fletcher
	<i>Tribrachiocrinus</i> sp.
	<i>Phialocrinus</i> cf. <i>konincki</i> (Clarke)
	<i>Glossopteris ampla</i> Dana
	<i>Glossopteris</i> sp.

The occurrence of these sediments on the edge of the Sydney Basin together with the spatial arrangement of leaf-rich pelites and sandstones containing a marine fauna indicated that a shoreline may have extended over the area. Because of this the surrounding area was surveyed accurately

to obtain the outcrop pattern and to plot the boundary between the pelites and sandstones. Using a scale of 1 inch equals 60 feet, a theodolite stadia traverse established control with sufficient accuracy for a 2 feet contour interval. This has been increased on the final plan to avoid congestion. Detail and geological boundaries were obtained using a telescopic alidade and plane table. The accuracy of the Permian-Silurian boundary to the east may be doubted due to the movement of Permian talus downslope and the superficial similarity of the Permian sandstone and Bungonia limestone lithologies. The heavily wooded nature of the terrain also hindered surveying.

The map resulting from the survey appears as Text-fig. 2.

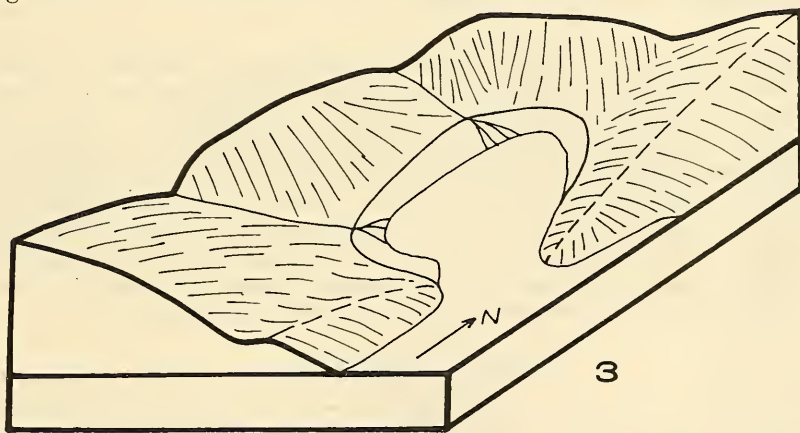


## DEPOSITIONAL INTERPRETATION

A division between pelites and sandstones is developed in the southern part of the Permian outcrop along an assumed topographic level of 973 feet to 979 feet. This is approximately 110 feet below the ridge top of Tangerang volcanics to the west. The lowest occurrence of Permian sediment is some 130 feet below this ridge. The ridge of Tangerang volcanics to the north and the eastern ridge formed by the Bungonia limestone are not as high topographically but enclose the Permian sediments on three sides with a topographical opening to the south.

In other areas on the edge of the Sydney Basin, the Permian is thin and in places is abnormal in character. The base of the Permian traces an irregular junction with older rocks so sediments such as these could have been deposited on a surface of some relief. It is possible that this area, affected by a period of Permian transgression contained many inlets and bays which received sediment transported from an eroding high composed of older rocks to the west. The South Marulan area may be interpreted as an inlet with the sandstones being in a littoral environment and the pelitic sediments representing a lagoonal or deltaic environment on the edge. The division between pelites and sandstones could be interpreted then as a shoreline. Subsequent erosion related to a period of regression in the Permian and post-Permian erosion would remove some of the sediments giving rise to the disposition of beds as in Text-fig. 2.

A possible reconstruction of the area in Permian time appears as Text-fig. 3.



Text-fig. 3. Block diagram showing possible topographic elements during deposition of South Marulan strata during Permian time.

We do not feel that the deposits can be representative of both transgression and regression. The marine sediments can be referred to a transgression but it is unlikely that the pelites are part of a regressive phase as one would expect sediments associated with such a regression to become coarser. A regression followed by a transgression is out of the question as the latter must be invoked to allow marine environment to cover the area.

The possibility that the sandstones may overlie pelites must be recognized. To the north and east, shorelines are formed and coarse sediments are overlain by finer sediments with a northerly or north-easterly dip (Craft, 1931). With such a situation here, the dip would be south-easterly but this would depend to some extent on associated Permian topography. Unfortunately no dips can be recorded from the South Marulan sediments.



If the marine deposits are littoral in origin, one would expect to find some evidence of turbulence near the junction with the pelitic sediments and evidence of quieter conditions some distance from this region. The fauna close to the supposed shoreline consists entirely of broken polyzoan detritus, ramose colonies of stenoporids and fenestellids with a large proportion of leaves. This supports a littoral origin. With increasing distance from the pelitic sediments, brachiopod and mollusc individuals increase in number with their valves united. Polyzoan colonies become more complete. Only near the edge of the littoral deposits is there evidence supporting turbulence. Elsewhere the fauna seems to have lived in relatively quiet conditions in shallow water. This would be in keeping with the possible physiographic position and the palaeogeography.

In considering the palaeogeography of the south-western portion of the Sydney Basin, one must take into account the study made by Gostin (1968). His thesis has shown that along the far south-western margin of the Basin in Permian time, sediments unconformably overlying pre-Permian basement become younger in a general north-westerly direction. This is based on faunal and field evidence. In the far south of the Basin, the lowest unit of the Conjola Formation unconformably overlies basement whereas to the west of Ulladulla, the topmost unit of the Conjola Formation, and further to the north-west, the Wandrawandian Siltstone and Nowra Sandstone overlie basement. In other words, there is a progressive transgressive phase in a north-westerly direction along the south and south-western margins of the Basin. The precise direction of the transgression cannot be determined at this stage due to the lack of satisfactory control points in the Nowra-Berry district.

Faunal evidence to support this transgression is adequate. Faunas in the lowest unit of the Conjola Formation are considered by Runnegar (in press) to be Dalwood equivalent, possibly correlative with the Allandale Formation. Further to the north-west, younger faunas in the topmost unit of the Conjola Formation and the Ulladulla Mudstone reveal similarities to faunas in the lower part of the Branxton Formation in the Hunter Valley. Therefore, it is not surprising that an analysis of the South Marulan fauna reveals that it is equivalent to fauna in high Wandrawandian Siltstone-low Nowra Sandstone. It is probably correlative with high Branxton or low Muree Formation. This is discussed in more detail subsequently.

#### SYSTEMATIC DESCRIPTIONS

Phylum MOLLUSCA

Class PELECYPODA

Superfamily ?

Family CONOCARDIDAE Neumayr

Genus *Conocardium* Bronn, 1835

*Type Species:* (by monotypy) *Cardium* (*Conocardium*) *elongatum* Sowerby, 1812, p. 188, pl. 82, fig. 3.

*Diagnosis:* See La Rocque, 1950, p. 317.

CONOCARDIUM sp.

(Pl. XIV, Figs 10-14)

In the description the shell is oriented in the sense of Branson (1942) and La Rocque (1950) and is the opposite of Fletcher (1943).

*Description:* Shells are equivalve and small. Anteriorly they are alate with a flattened area near the hinge line. A characteristic key-hole shaped ventral gape is developed along more than half the anterior ventral margin

which is slightly curved. The region adjacent to the gape on an internal mould is crenulate with more than 13 crenulations present. They decrease in size and are more closely spaced posteriorly, and can be traced from the margin to the umbonal region. Concentric ornament is not developed as strongly. Carinae are not well developed. The semi-crescentic posterior area is ornamented with 15 or more radial, and concentric plicae, producing small inflections on the slightly curved margin. The posterior tube is produced closer to the umbones than to the posterior extremity. Umbones are small and centrally situated. The hinge line is straight and long. The anterior ligament area is long and narrow and the posterior area is large and wide.

On an external mould, 24 primary radial ribs can be traced from the umbonal region to the anterior ventral margin. This number increases near the margin as secondary ribs arise between the primaries.

*Discussion:* This species has morphological resemblances to *Conocardium robustum* Fletcher, 1943, because of its strongly inflated carinal area, the shape of the anterior gape and the oblique nature of the carina. It is much smaller than this species but this may be due to immaturity. The species has a more oblique carina than *Conocardium australe* (McCoy).

Specimens catalogued from South Marulan are S.U.P. (Sydney University Palaeontological Collection) 12622 A, B, C.

*Dimensions:* These are related to the long, straight anterior region.

12622 (right valve)	Length.....27 mm.
	Height.....20
	Thickness...10

#### Superfamily CARDITACEA ?

##### Family MYOCHONCHIDAE Newell

##### Genus *Stutchburia* Etheridge, Jr, 1900

*Type Species:* (by original designation) *Orthonota* ? *costata* Morris, 1845, p. 273, pl. 11, fig. 1, from the Permian of the Illawarra region, New South Wales.

*Diagnosis:* See Dickins, 1963, p. 95.

##### STUTCHBURIA COSTATA (Morris), 1845

(Pl. xiv, Figs 1-5)

*Diagnosis:* Shell slightly expanded towards rear; radial plications confined to posterior portion of the shell.

*Description:* Shells become slightly higher and elongate posteriorly; umbones are not prominent; a long deep ligament groove is placed posterior to the umbones. There is a great variation in size. Morphology developed is constant except for the muscle scars. On all specimens the anterior adductor scar has a prominent posterior buttress. This is higher dorsally and wider anteriorly. However, on small specimens the anterior region of this scar overhangs the margin. This is not so with larger specimens in which the anterior adductor scar is divided into a dorsal one-third and a ventral two-thirds by a low ridge which is higher dorsally. Posterior scars are nearly semi-circular with the diameter paralleling the hingeline but they are slightly asymmetrical towards the anterior. Anterior scars are oval. Elongate, narrow pedal scars are evident in front of the umbo on all specimens. The pallial line is entire meeting the anterior scar at its postero-lateral margin and the posterior scar in its ventral region. The hinge is edentulous with a slight twist to the right in front of the umbones. Ornamentation consists of con-



centric growth lines and upwards of 5 strong radial plicae in the posterior region.

*Discussion*: The occurrence of a form possessing coarse costae with a subdivision of the anterior adductor scar by a ridge is interesting as Etheridge (1900) stated that the coarse costae were characteristic of *S. costata* whereas the latter feature was characteristic of *S. compressa*. Further studies may show the two species to be identical.

Specimens catalogued are S.U.P. 12610–12614, 12615, A, B, C, 23573 A, B, C.

*Dimensions*: (right valve)

	Length	Height	Thickness
23573A	63.0	25.0	9.5 mm.
12610	9.6	6.0	2.5 mm.
12611	5.1	2.9	1.0 mm.

Superfamily PECTINACEA  
Family LIMIDAE d'Orbigny  
Genus *Elimata* Dickins, 1963

*Type Species*: (by original designation) *Elimata guppyi* Dickins, 1963, p. 93, pl. 15, figs 6–13, from the base of the Permian, Poole Sandstone, Western Australia.

*Diagnosis*: See Dickins, 1963, p. 93.

ELIMATA PRIMA, sp. nov.

(Pl. xiv, Figs 6–9)

*Holotype*: 12607 S.U.P. from the northern section of Permian sediments at 70493024 Wollongong 1:250,000 Geological Series Sheet SI 56–9, approximately one mile south-west of South Marulan, New South Wales.

*Diagnosis*: Robust, convex, markedly opisthocline shells with a short, straight hinge line.

*Description*: Shells are opisthocline with a short, straight hinge line. Weakly developed umbonal ridges separate small flattened areas from the rest of the shell. The posterior ridge is sharper and more distinct than the rounded anterior ridge which produces a steep slope on the dorsal antero-lateral region of the shell. Concentric growth lines are present and sometimes fine radiating plicae can be observed near the ventral margin.

*Discussion*: This species is larger, more opisthocline and possesses a shorter hinge line than the type species. This is the first published record of the genus from the Eastern Australian Permian strata. Dickins (1964) referred to *Elimata* sp. nov. from the Ingelara Formation in the south-western portion of the Bowen Basin, Queensland.

Specimens catalogued from South Marulan are S.U.P. 12606–12609.

*Dimensions*: (right valve)

	Length	Height	Thickness
12607	13	12	2.0 mm.
12609	13+	15	2.5 mm.

Phylum BRACHIOPODA  
Class ARTICULATA  
Order TEREBRATULIDA  
Family DIELASMATIDAE Schuchert  
Genus *Fletcherithyris* Campbell, 1965

FLETCHERITHYRIS cf. AMYGDALA (Dana), 1847

(Pl. xv, Figs 7, 11)

*Remarks:* Specimens assigned to this species show some variation from those described by Campbell. One has a characteristic V-shaped septalium with growth lines normal or directed slightly posteriorly to its length. This is different from *F. amygdala* (Dana) where they are directed mainly anteriorly (Campbell, 1965, pl. 6, figs 24, 32) and *F. farleyensis* Campbell in which they are directed posteriorly (Campbell, 1965, pl. 6, fig. 4). The septalium developed is of similar length to *amygdala* and similar to *farleyensis* in height. The lateral commissure is intermediate between these two species (Campbell, 1965, pl. 6, figs 7, 29).

A specimen smaller than the normal *farleyensis* may be *F. farleyensis faba* Campbell but the characteristics anterior flattening of the pedicle valve in the latter species is not conspicuous. Growth lines on the septalium are normal to its length.

Specimens catalogued are S.U.P. 25557-25558.

*Dimensions:*

	Length	Width	Height
25557	31	22	13.5 mm.
25558	21	14	8.0 mm.

## Order SPIRIFERIDA

## Family MARTINIIDAE Waagen

Genus *Notospirifer* Harrington, 1955

*Type Species:* (by original designation) *Spirifer darwini* Morris, 1845, p. 279 from the Permian, ? Muree Formation at Glendon, Hunter Valley, New South Wales.

*Diagnosis:* See Campbell, 1959, p. 342; Waterhouse and Vella, 1965, p. 70.

NOTOSPIRIFER cf. MINUTUS Campbell, 1960

(Pl. xv, Figs 1-5)

*Remarks:* Specimens from South Marulan show much variation in external morphology. In none could the fold in the brachial valve be described as being flat on top. There is a gradation from folds with a shallow sinus to folds with a strong sinus developed. Specimens with the latter feature are considered to be gerontic, this being based also on the nature of the plications. The sulcus of the pedicle valve can have a small fold developed along its midline. In mature specimens, the number of plications is the same in *N. minutus* but they are more strongly developed. In younger specimens the greatest width is more posterior than in older specimens.

Internally the ventral adminicula are similar to those figured by Campbell (1960, pl. 140, fig. 7) and only in small specimens do they tend to become subparallel posteriorly. Dorsal adminicula are shorter than the ventral and widely divergent. They are noticeably longer on specimens with five well developed plicae.

Specimens catalogued from South Marulan are S.U.P. 25544, 25549-52, 25555, 25560, 25561, 25565, 25572, 25573, 25576.

*Dimensions:* (brachial valve)

	Length	Width	Height
25551	15	28	6.8 mm.
25552	13	23	9.0 mm.
25572	20	36	8.0 mm.
25573	20	39	10.0 mm.

Order STROPHOMENIDA  
 Family LINOPRODUCTIDAE Stehli  
 Genus *Terrakea* Booker, 1930

*Type Species*: *Productus brachythaerus* Morris, 1845, from the Permian of New South Wales. (See Maxwell, 1956, Heming, 1957.)

*Diagnosis*: See Moore, 1965, p. H503.

TERRAKEA sp.

(Pl. XIV, Fig. 19)

*Remarks*: Fragmentary remains from South Marulan reveal a wide, straight hinge line. Umbonal shoulders are not steep and the umbo which is blunt and not strongly thickened only slightly overhangs the hinge line. Diductors are longitudinally striated; adductors are finely dendritic.

Features of the umbonal region indicate that this species is remarkably similar to *Terrakea* sp. from the Ingelara Formation and Catherine Sandstone of the Springsure 1:250,000 Sheet area of Queensland. The blunt nature of the umbo with an absence of strong thickening enables a separation from *Terrakea solida* which is found generally at a higher stratigraphic horizon.

Specimens catalogued from South Marulan are S.U.P. 25540, 25545.

Phylum POLYZOA  
 Class GYMNOLOEMATA  
 Order TREPOSTOMATA

Family STENOPORIDAE Waagen and Wentzel  
 Genus *Stenopora* Lonsdale, 1844

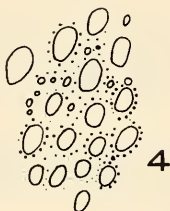
*Type Species*: (by subsequent designation of Ulrich, 1890, p. 375) *Stenopora tasmaniensis* Lonsdale, 1844, p. 178 from the Permian of Southern Tasmania.

*Diagnosis*: Zoarium massive, ramose, encrusting, bilaminar; zooecial tubes thin walled in axial region and exhibiting a definite annulated habit in the peripheral region; diaphragms absent; apertures oval or rounded, mesopores and acanthopores present; maculae and monticules may be developed.

STENOPORA GRACILIS (Dana), 1849

(Text-fig. 4)

*Diagnosis*: Ramose zoarium with a narrow peripheral region and two or three rows of annulations; mesopores not well developed, acanthopores numerous; maculae irregular.



Text-fig. 4. Oblique tangential section through *Stenopora gracilis*, 16431,  $\times 10$ .

*Remarks*: Specimens from South Marulan possess ramose zoaria with a diameter of 1.0–5.0 mm. The peripheral region is 1.2 mm. wide in a zoarium of diameter 5.0 mm. Zooecial tubes leave the axis at an angle of  $35^{\circ}$ – $40^{\circ}$  and in the peripheral region they are normal to the periphery.



The small, ramose zoaria and the nature of the peripheral region are considered adequate to include these specimens in *Stenopora gracilis*. The species, *S. nigris* Crockford is similar to *S. gracilis*. According to Crockford (1943) both are characterised by a narrow, peripheral region with two rows of annulations, numerous acanthopores and few mesopores. *S. gracilis* is the finer species but an examination of S.U.P. material reveals that measurements are more similar to *S. nigris* than those stated by Crockford.

Specimens catalogued are S.U.P. 16431-16438.

#### AGE AND CORRELATION

Recent work by Campbell (1965), Dickins, Gostin and Runnegar (in press), Gostin (1968) and Runnegar (in press) together with studies made during this decade in the Permian of Queensland, particularly by Dickins (in press) enable a reasonable correlation and stratigraphic analysis of the South Marulan fauna to be made with similar faunas on the South Coast and Hunter Valley in New South Wales and with the Bowen Basin in Queensland. Many species are long ranging and of little value. A conspicuous feature of the fauna is the absence of genera such as *Taeniothaerus*, *Grantonia*, *Deltopecten* and *Eurydesma* and particular species of the genera *Notospirifer*, *Cancrinella*, *Terrakea* and *Ambikella*. This immediately indicates that the fauna is younger than Fauna II in the Bowen Basin and similar faunas elsewhere. However, species such as *Keeneia ocula*, *Gilledia* cf. *ulladullensis*, *Fletcherithyris parkesi*, *Ambikella* cf. *isbelli* and *A.* cf. *undulosa* are recorded from the Conjola Formation, partly equivalent to Fauna II (Dickins *et al.*, in press).

The use of species of *Ambikella* for correlative purposes in the South Coast and Hunter Valley Permian sequences has limited value as most species were originally described from Queensland and those in the Sydney Basin are in urgent need of critical examination. Therefore, all species of *Ambikella* from South Marulan are prefixed by cf. It is worthy of note that the species possess a shallow sulcus and the adminicula are elongated in the brachial valve. These are considered to be features of *Ambikella* spp. in Fauna III of the Bowen Basin.

Species from South Marulan regarded as significant and of use in correlation are *Fletcherithyris* cf. *amygdala*, *Notospirifer* cf. *minutus*, *Terrakea* sp., *T. solida*, *Pleurikodonta* cf. *elegans* and *Vacunella* cf. *curvata*. The occurrence of *Elimata prima*, sp. nov. may be of some value as is the absence of the terebratuloid *Marinurnula*. In the southern region of the Sydney Basin the absence of this genus is of stratigraphic significance as it indicates that the fauna is not younger than the Nowra Sandstone (Campbell, 1965).

Of the South Marulan species, Dickins *et al.* (in press) record *Strophalosia* cf. *clarkei*, *Terrakea* sp. and *Fletcherithyris amygdala* from the Wandrawandian Siltstone and *Vacunella* cf. *curvata*, *Notospirifer* cf. *minutus*, *Strophalosia* cf. *clarkei* and *Ambikella* cf. *isbelli* from Nowra Sandstone. Of the other species considered significant, *Pleurikodonta elegans* has been recorded by Runnegar (1965) from Fauna IV and possibly high Fauna III in the Bowen Basin. This is the first record of the genus outside this area. *Atomodesma* (*Aphanaia*) sp. has been identified from the Oxtrack Formation (low Fauna IV) and in the Springsure area, *Elimata* occurs first in the Ingelara Formation (middle Fauna III) and in strata containing a high Fauna III there is an incoming of *Terrakea* sp. and *Notospirifer* cf. *minutus*. The boundary between the Nowra Sandstone and the Wandrawandian Silt-

stone may be equivalent to the upper part of the Gebbie Subgroup (high Fauna III) in the Bowen Basin. It seems therefore, that the South Marulan strata may be best correlated with the strata about the Wandrawandian Silstone-Nowra Sandstone boundary. Considering the Hunter Valley sequence in terms of the South Marulan fauna, correlation with the upper part of the Bransford Formation or low Muree Formation is suggested.

*Terrakea solida* occurs only in Fauna IV. *Aviculopecten subquinque-lineatus*, *Keeneia minor*, *Stutchburia costata*, *Gilledia ulladullensis*, *Fletcherithyris parkesi* and *Fenestella canthariformis* together with species of *Ambikella* appear high or low in the sequence and it seems that correlatives of Fauna III in the southern Sydney Basin contain species found in Faunas II and IV as well as Fauna III of the Bowen Basin. Dickins *et al.* (in press) have already recognised this feature and consider that it may be due to either an hiatus during Fauna III time in the South Coast sequence or to the faunas appearing at slightly different times due to geographical and environmental factors.

A complete faunal study of the South Coast Permian sequence, especially the productids, spiriferids and pelecypods would be beneficial and as a result, correlation of the South Marulan strata with the South Coast sequence may need revision.

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#### References

- BOOKER, F. W., 1930.—A review of some of the Permo-Carboniferous Productidae of New South Wales with a tentative reclassification. *J. Proc. r. Soc. N.S.W.*, 64: 65-77.
- BRANSON, C. C., 1942.—Correction of homonyms in the lamellibranch genus *Conocardium*. *J. Paleont.*, 16(3): 387-392.
- BROWNE, W. R., ed., 1950.—The Geology of the Commonwealth of Australia. 3 vols, Edward Arnold and Co., London.
- CAMPBELL, K. S. W., 1959.—The Martiniopsis-like Spiriferids of the Queensland Permian. *Palaeontology*, 1(4): 333-350.
- , 1960.—The brachiopod genera *Ingelarella* and *Notospirifer* in the Permian of Queensland. *J. Paleont.*, 34(6): 1106-1123.
- , 1965.—Australian Permian Terebratuloids. *Bull. Bur. miner. Resour. Geol. Geophys. Aust.*: 68.
- CRAFT, F. A., 1931.—The physiography of the Shoalhaven River Valley. 1. Tallong-Bungonia. *Proc. LINN. Soc. N.S.W.*, 56(2): 99-132.
- CROCKFORD, J., 1943.—Permian Bryozoa from eastern Australia, Part III; Batostomellidae and Fenestrellinidae from Queensland, New South Wales and Tasmania. *J. Proc. r. Soc. N.S.W.*, 76(4): 258-267.
- DANA, J. D., 1847.—Descriptions of fossils from Australia. *Am. J. Sci.*, 54: 151-160.
- , 1849.—In United States exploring expedition during the years 1838-1842 under the command of Charles Wilkes, U.S.N. 10, Geology: 681-713.
- DICKINS, J. M., 1963.—Permian Pelecypods and Gastropods from Western Australia. *Bull. Bur. miner. Resour. Geol. Geophys. Aust.*: 63.
- , 1964.—Permian macrofossils from the Springsure sheet area. In *Rec. Bur. miner. Resour. Geol. Geophys. Aust.*, 1964/27 (unpubl.).



- , (in press).—Correlation of the Permian of the Hunter Valley, New South Wales with the Bowen Basin, Queensland. *Bull. Bur. miner. Resour. Geol. Geophys. Aust.*: 80.
- , GOSTIN, V. A., and RUNNEGAR, B. (in press).—Correlation and age of the Permian sequence in the southern part of the Sydney Basin, New South Wales. Essays in honor of Dorothy Hill. A.N.U. Press.
- ETHERIDGE, R., jr, 1900.—Little-known and undescribed Permo-Carboniferous Pelecypoda in the Australian Museum. *Rec. Aust. Mus.*, 3(7): 178-187.
- FLETCHER, H. O., 1943.—The genus *Conocardium* from Australian rocks. *Rec. Aust. Mus.*, 21(4): 231-243.
- FLINTER, B., 1950.—The geology of the Bungonia area. Unpubl. Hons Thesis, University of Sydney.
- GOSTIN, V. A., 1968.—Lower Permian Sediments, southern extremity, Sydney Basin, New South Wales. Unpubl. Ph.D. Thesis, A.N.U., Canberra.
- GOULD, I. G., 1966.—The general geology of an area south of Marulan, New South Wales. Unpubl. Hons Thesis, University of Sydney.
- HARRINGTON, H. J., 1955.—The Permian *Eurydesma* fauna of Eastern Argentina. *J. Paleont.*, 29: 112-128.
- HEMING, F., ed., 1957.—Opinion 486. *Int. Comm. zool. Nom.*, 17(8): 105-118.
- HIND, M., 1950.—Contribution to a study of the Marulan Batholith. Unpubl. Hons Thesis, University of Sydney.
- LA ROCQUE, A., 1950.—Pre-Traverse Devonian Pelecypods of Michigan. *Contr. Mich. Mus. Paleont. Univ. Mich.*, 7(10): 271-366.
- LONSDALE, W., 1844.—In DARWIN, C., Geological Observations. Elder Smith, London.
- LOVERING, J. F., 1950.—Contribution to a study of the Marulan Batholith. Unpubl. Hons Thesis, University of Sydney.
- MAXWELL, W. G. H., 1956.—Proposed use of the plenary powers to designate a type species in harmony with accustomed usage for *Terrakea* Booker, 1930. *Bull. zool. Nom.*, 11(11): 333-336.
- MOORE, R. C., ed., 1965.—Treatise on Invertebrate Paleontology, Part H. Univ. Kansas Press for Geological Society of America.
- MORRIS, J., 1845.—In STRZELECKI, P. E. DE, Physical Description of New South Wales and Van Diemen's Land. Longmans, London.
- NAYLOR, G. F. K., 1939.—The age of the Marulan Batholith. *J. Proc. r. Soc. N.S.W.*, 73(2): 82-85.
- OSBORNE, G. D., 1931.—The Contact Metaphorism and related phenomena in the neighbourhood of Marulan, New South Wales. 1. *Geol. Mag.*, 68: 289-314.
- , 1949.—Contribution to a study of the Marulan Batholith. *J. Proc. r. Soc. N.S.W.*, 82: 116-128.
- , and LOVERING, J. F., 1952.—Contribution to a study of the Marulan Batholith. II. *Ibid.*, 86: 108-118.
- RUNNEGAR, B. N., 1965.—The bivalves *Megadesmus* Sowerby and *Astartila* Dana from the Permian of eastern Australia. *J. geol. Soc. Aust.*, 12(2): 227-252.
- , (in press).—Brachiopoda and Mollusca from the base of the Permian sequence, South Coast of New South Wales. Essays in honour of Dorothy Hill. A.N.U. Press.
- SHERRARD, K., 1949.—Graptolites from Tallong and the Shoalhaven Gorge, New South Wales. *Proc. LINN. Soc. N.S.W.*, 74: 62-82.
- SOWERBY, J., 1812.—The Mineral Conchology of Great Britain. I. Meredith, London.
- SVENSON, D., 1950.—Contribution to a study of the Marulan district. Unpubl. Hons Thesis, University of Sydney.
- ULRICH, E. O., 1890.—Paleozoic Bryozoa. *Bull. Ill. geol. Surv.*, 8(2): 283-688.
- WATERHOUSE, J. B., and VELLA, P., 1965.—A cold water Permian fauna from North-west Nelson, New Zealand. *Trans. roy. Soc. N.Z. Geol.*, 3(5): 57-84.
- WOOLNOUGH, W. G., 1909.—The general geology of Marulan and Tallong, New South Wales. *Proc. LINN. Soc. N.S.W.*, 34: 782-808.

## EXPLANATION OF PLATES

## PLATE XIV

*Stutchburia costata*

Fig. 1. 23573A, internal mould of a right valve,  $\times 1$ . Fig. 2. 23573C, external cast of ornament,  $\times 1$ . Fig. 3. 23573A, internal mould showing hinge line,  $\times 1$ . Fig. 4. 12611, internal mould of right valve showing overhang of anterior adductor scar,  $\times 8$ . Fig. 5. 23573A, internal mould of left valve showing ridge in anterior adductor scar, pedal retractor and pallial line,  $\times 3$ .



*Elimata prima*, sp. nov.

Fig. 6. 12607, internal mould of left valve,  $\times 2$ . Fig. 7. 12606, internal mould of right valve,  $\times 2$ . Fig. 8. 12609, internal mould of right valve,  $\times 2$ . Fig. 9. 12607, side view of internal mould of left valve,  $\times 2$ .

*Conocardium* sp.

Fig. 10. 12622C, external cast of ornament on right valve showing secondary ribs developing between primaries,  $\times 2$ . Fig. 11. 12622A, internal mould of right valve,  $\times 1.5$ . Fig. 12. 12622A, internal mould showing keyhole shaped ventral gape,  $\times 1.5$ . Fig. 13. 12622A, umbonal view of internal mould showing straight hinge line and posterior tube,  $\times 1.5$ . Fig. 14. 12622A, posterior view of internal mould showing position of posterior tube and inflections on margin produced by plicae,  $\times 1.5$ .

*Pleurikodonta* cf. *elegans*

Fig. 15. 12624A, anterior view of internal mould,  $\times 2$ . Fig. 16. 12624B, external mould showing crenulate commissure,  $\times 3$ . Fig. 17. 12616, internal mould showing megadesmatid tooth fold,  $\times 4$ .

*Strophalosia* cf. *clarkei*

Fig. 18. 25539, internal mould of pedicle valve,  $\times 1.5$ .

*Terrakea* sp.

Fig. 19. 25540, oblique view of umbonal region on internal mould of pedicle valve,  $\times 1$ .

## PLATE XV

*Notospirifer* cf. *minutus*

Fig. 1. 25572, internal mould of brachial valve,  $\times 2$ . Fig. 2. 25551, posterior view of internal mould,  $\times 2$ . Fig. 3. 25572, posterior view of internal mould showing sinus in fold of brachial valve,  $\times 2$ . Fig. 4. 25552, internal mould of pedicle valve,  $\times 2$ . Fig. 5. 25551, internal mould of anterior commissure,  $\times 2$ .

*Fletcherithyris* *parkesi*

Fig. 6. 23452, internal mould of brachial valve,  $\times 1.5$ . Fig. 12. 23452, internal mould of anterior commissure,  $\times 1.5$ .

*Fletcherithyris* cf. *amygdala*

Fig. 7. 25557, lateral commissure on internal mould,  $\times 1.5$ . Fig. 11. 25557, internal mould of brachial valve,  $\times 1.5$ .

*Gilledia ulladullensis*

Fig. 8. 25559, internal mould of brachial valve,  $\times 1.5$ . Fig. 9. 25559, internal mould of pedicle valve,  $\times 1.5$ . Fig. 10. 25559, anterior commissure on internal mould,  $\times 1.5$ . Fig. 13. 25559, lateral commissure on internal mould,  $\times 1.5$ .

*Ambikella* cf. *isbelli*

Fig. 14. 23451, anterior commissure on internal mould,  $\times 1$ . Fig. 15. 23451, internal mould of pedicle valve,  $\times 1.5$ . Fig. 16. 23451, posterior view of internal mould,  $\times 1.5$ .

*Ambikella* cf. *undulosa*

Fig. 17. 25579, internal mould of pedicle valve,  $\times 1$ .